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Soil-Depleting Soil-Conserving and Soil-Building Crops

SOIL-DEPLETING, SOIL-CONSERVING, AND SOIL-BUILDING CROPS[1]

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The Soil Conservation Service is vitally interested in conserving the soil by using the land properly. Some crops are said to be "soil depleting," some "soil conserving," and others "soil building." These crops differ in their effect on the conservation of soil and water. It seems desirable that the meaning of these terms and the reasons why some crops are soil-depleting, some soil-conserving, and others soil-building should be well understood.

The terms "soil-depleting," "soil-conserving," and "soil-building crops" must not be confused with soil-depleting, soil-conserving, and soil-building practices. A soil may be depleted by a bad practice though no crops are grown. Soil-conserving and soil-building practices involve the application of lime and fertilizers, the practice of rotations, and the use of other measures that go beyond the mere use of certain crops.

Soil

There are many kinds of soils, ranging all the way from light sands to silts and heavy clays. Soils differ in texture as well as in the kinds and quantities of plant food they contain. For present purposes we may say that a soil is an aggregation of minerals derived from the decay of rocks, plus organic matter. Surface soils vary from a few inches to a considerable depth. Subsoils differ from surface soils in various ways but particularly in having a lower organic-matter content.

Organic Matter In Soil

The organic matter is the home of micro-organisms, whose activity makes plant food available to crop plants. Mention may be made of *Azotobacter*, forms which are able to use atmospheric nitrogen, provided energy material is available. This they find in the organic matter. Organic matter also influences the texture of the soil. It is, therefore, quite as important a part of the soil as the minerals.

Minerals In Soil

Plants need a variety of minerals for nutrition, but the ones that commonly need to be considered in agricultural practice are lime, phosphorus, potash, and occasionally magnesium. Under certain conditions elements such as manganese, boron, copper, iron, and zinc may be added to soils to advantage, and in rare cases, some of the less-common minerals. Plants also need nitrogen, but that does not come from the decomposed rock. A soil may be depleted with respect to its mineral plant food or with respect to its organic-matter content or both. Let us define a soil-depleting crop and consider the loss of minerals and of organic matter.

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Soil-Depleting Crops

A soil-depleting crop may be defined as one that causes the destruction of organic matter or the loss of minerals in excess of those carried away in the crop. The organic matter is lost because the crop requires excessive cultivation. Minerals are lost because the crop leaves the soil exposed to erosion. The term is a relative one; some crops are more soil depleting than others. Small-grain crops allow some erosion and, whether harvested or not, are never true soil-conserving crops. There is, however, less soil depletion than when corn or cotton is grown.

If a small-grain crop is interplanted with clover or lespedeza and the legume covers the ground by the time the grain is harvested, probably as much organic matter will be left in the soil as is lost. There will be even more left in the soil if the grain is pastured down. A combination of a small-grain crop and clover or lespedeza pastured or left on the land tends to conserve the soil.

Depletion of Minerals

All the lime, phosphorus, and potash in the body of a plant has been taken from the soil in which it grew; there is no other place the plant can get it. If these plants are grazed or otherwise removed from the soil on which they grow, just so much lime, phosphorus, potash, and other minerals as they contain are removed from the soil. If the plants are left to decay in place or are turned under, the minerals they contain are returned to the soil. The mineral content of soils may be depleted by cropping, by leaching, or by erosion; it may be conserved by proper farming practices that reduce leaching and erosion, but it cannot be increased by any form of cropping. When minerals are needed they must be added. All harvested crops remove something from the soil and insofar the soil is depleted. Cotton and corn are classed as soil-depleting crops; most hay crops as soil conserving.

Plant Food Removed by a Crop

However, from the standpoint of the plant food removed, a cotton crop is no more soil depleting than a crop of Bermuda grass hay. An average cotton crop of 204 pounds of lint and 368 pounds of seed will remove from the soil about 13.3 pounds of nitrogen; 5.3 pounds of phosphoric acid; 5.4 pounds of potash, and 1.3 pounds of lime. This is assuming that leaves and stalks go back into the ground (fig. 1). For Bermuda grass hay, the corresponding figures per ton of hay are 23.36, 4.0, 28.4, and 9.6 pounds, respectively. A crop of seed cotton removes from the soil a little more phosphoric acid but less potash, lime, and nitrogen than a crop of Bermuda grass hay. From the standpoint of the amount of plant food removed, cotton is therefore no more soil depleting than hay. The fact that hay removes from the soil a comparatively large amount of plant food was also pointed out by J. S. Cutler, conservator for Region 3 of the Soil Conservation Service, who showed that a 4-ton per acre yield of alfalfa removed more nutrients than a 50-bushel per acre yield of corn.

Cotton and corn are considered soil depleting because of the chance they give for erosion. If they could be grown under conditions that eliminate erosion, they would be no more soil depleting than hay.

The quantities of minerals removed by plants are small in comparison with those lost by erosion, but on the soils less well supplied with minerals the steady withdrawal of plant food through the years has a considerable effect and cannot be ignored. Old grass pastures become poorer with the lapse of time because the constant removal of

herbage as milk and meat means the slow depletion of the soil. In addition to the nitrogen removed, with every 1,000 pounds of milk produced by cows on pasture, about 1.6 pounds of lime and 2 pounds of phosphoric acid are carried away. With every ton of alfalfa hay 39 pounds of lime, 10.8 pounds of phosphoric acid, and 44.6 pounds of potash are removed; and the soil is depleted to that extent. Timothy removes 5 pounds of lime, 3.6 pounds of phosphoric acid, and 13.4 pounds of potash in every ton of hay.

This depletion of the soil of minerals simply cannot be avoided if the crop is to be utilized. In the course of time these minerals will have to be replaced. If they are not replaced, a gradual decline in productivity may occur even without erosion. Fortunately, replacement of minerals is not very expensive and pays well.

FIGURE 1.—This crop of cotton has depleted the soil because it has permitted erosion.

Depletion of Organic Matter

Organic matter is essential to soil, and nitrogen, an important food element, is present in it. Soil-conserving and soil-building crops must be considered chiefly in terms of the effect these crops have on the organic matter in soils.

Where soil is covered with a sod the organic matter is increased rather than diminished, but where a cultivated crop is grown, whether a legume or a nonlegume, organic matter is consumed; it is literally burned up.

The destruction of organic matter is brought about by a process of oxidation through the growth of micro-organisms. This process is hastened by the aeration of the soil that follows cultivation. The more intensive the cultivation, therefore, especially in warm sections, the greater the destruction of organic matter. Here soil erosion also plays a great part. The organic matter is mainly in the surface soil. It is this surface soil that is washed away, and the organic matter goes with it. Erosion too is facilitated by the stirring of the soil. Soil-depleting and soil-conserving crops should therefore be considered in relation to their effect on the organic matter as well as on the minerals in the soil. Soil-building crops can effect a change only in the amount of organic matter in the soil.

It is certain that soil erosion plays a greater part than the mere

removal of crops in soil depletion, especially when these crops are removed by grazing animals. The problem rightly considered is therefore mainly a matter of soil erosion. But it must not be forgotten that even where there is no erosion, cultivation itself tends to destroy the organic matter; and consequently all cultivated crops stand at the top of the list of soil robbers.

Soil-Conserving Crops

On the other hand, crops that can be grown with a minimum of stirring the soil are in varying degrees soil-conserving crops. As pointed out, the minerals in the soil cannot be wholly conserved if the crop is to be utilized; but the loss of minerals, except from erosion, is not heavy, and minerals can be economically replaced. Noncultivated crops, such as alfalfa, clover, lespedeza, Kudzu, grass hay, and pasture, conserve the organic matter in the soil, and that is the important thing (fig. 2, *A* and *B*). The growing of these crops, therefore, tends to conserve the soil even if some minerals are carried away in the crop.

These close-growing crops prevent erosion with its attendant loss of organic matter and minerals. The annual stirring of the soil necessary to the culture of a small-grain crop occasions some loss of organic matter and allows more erosion than is permitted by a meadow or pasture (fig. 2, *C*). A small-grain crop can be called a soil-conserving crop, therefore, only by comparison with a crop that is more soil depleting, such as corn or cotton. In comparison with a meadow, small grain is a soil-depleting crop. Again it may be pointed out that the term "soil-conserving crop" is a relative one. Crops conserve the soil to the degree to which their culture is possible with a minimum of soil stirring and in proportion to the density and permanency of cover they provide. The removal of plant food by the plant, which is a necessary accompaniment of utilization, plays a minor part in soil depletion. The concept of soil conservation covers the maintenance of soil productivity, and those crops that best serve to maintain the productivity of a soil while being utilized are the best soil-conserving crops.

Soil-building Crops

Soil-building crops must go further; they must not only conserve what is there but must build it up, make the soil better. Here again it is the organic matter that counts. Plants cannot build up the minerals; all they have came from the soil; if the plants are turned under, just so much goes back to the soil. If the soil needs more lime, phosphorus, or potash it must be added.

Plants can, however, build up the organic matter and with it the nitrogen content of the soil. Legumes, of course, work best as nitrogen gatherers. They get a large part of their nitrogen from the air, and if they are turned under, the soil will have that much more nitrogen. In this connection, the kind of legume used and the way it is used must be considered. Soybeans cultivated in rows and harvested as hay are about as competent soil robbers as corn. They permit erosion and the destruction of organic matter. Even when the soybeans have been well inoculated there is more nitrogen in the soybean hay than the plant took from the air, and since the root system is relatively small, little nitrogen is returned to the soil. This statement applies equally well to other annual legumes, such as cowpeas and velvetbeans, if they are removed from the ground. When these crops are broadcast or planted in close drills they help somewhat to

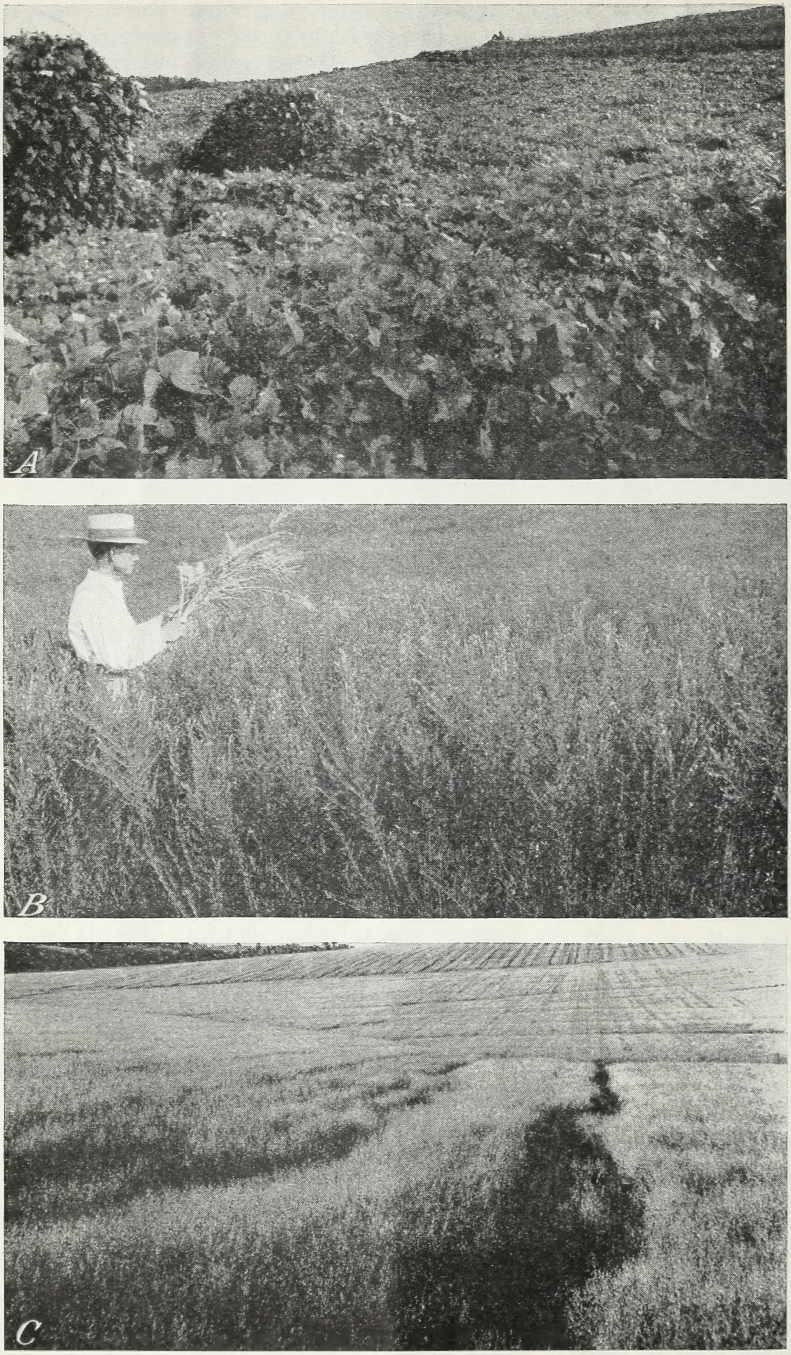

FIGURE 2.—*A*, Kudzu protects this slope and conserves organic matter and minerals; *B*, lespedeza conserves this field, which was beginning to gully, even though minerals are removed in the hay; *C*, a small grain is not a true soil-conserving crop, but erosion is less under a small-grain crop than under a cultivated crop.

stop erosion, but if harvested they do not build soil. That is possible only when they are turned under. Even when they are turned under, little benefit may be derived from the nitrogen unless another crop is ready to use it. Turning under a summer legume in the fall and leaving the ground bare is a wasteful practice. Most of the nitrogen derived from the legume is lost during winter by erosion or leaching. This is not the fault of the crop but of the practice.

All annual legumes have relatively poor root systems, usually not exceeding 10 to 12 percent of the total weight of the plant. In red clover, on the other hand, about one-third of the total plant weight is underground. Even when a red clover crop is removed, considerable quantities of organic matter and nitrogen remain to maintain soil productivity.

When soil-building crops are discussed, therefore, it is not enough to suggest the use of legumes. It is necessary to specify not only the kind of legume, but also how it must be used to help in soil building. Soil building is an extremely slow process. The reference here is not to the geological concept of soil building, which is a process going on from below. The term is used in its agricultural meaning of permanently raising the productive capacity of a soil. In this sense, soil building by cropping can take place in only one direction—an increase in the organic-matter content of the soil. If this can be accomplished, other effects, physical and chemical, will follow. The mineral content of a soil, to be sure, will not be increased by cropping, though it may be conserved by preventing wastage. It has been shown that in a sandy soil in a hot climate a permanent increase in organic matter simply does not occur. A heavy crop of legumes plowed under on such a soil is burned up by cultivation in one season. On heavier soils and in a cooler climate there is some increase in organic matter when plants are turned under, but it is very slow. If a crop of vetch that would cut a ton of hay per acre is turned under, one-half or more is quickly lost by decay, mostly as carbon dioxide. Of the remainder, some is later lost, and only a small part is added to the organic matter of the soil.

Soil Building a Slow Process

Allowing for loss of organic matter in the cultivation of the summer crop, it would probably be more than 100 years before the organic matter in a soil containing 2 percent of organic matter could be doubled by the practice of turning under a good green-manure crop every year. It is more correct, therefore, to speak of green manuring as a soil-conserving rather than as a soil-building practice. The best that can be hoped for is to maintain the organic matter at a level satisfactory for crop production. Green manuring combined with erosion-control practices should maintain the productivity of the soil.

The soil building commonly referred to in agricultural practice is a temporary process. It is quite true that when a green-manure crop is turned under, the soil is temporarily more productive than it would have been if that crop had not been turned under. This is due in part to the additional nitrogen supplied when a legume is turned under and in part to an increase in organic matter. If this organic matter were not later removed by cultivation the soil might be built up, but it is removed, at least in great part. The organic matter must be constantly renewed if the productivity of the soil is to be maintained. This is soil conservation rather than soil building.

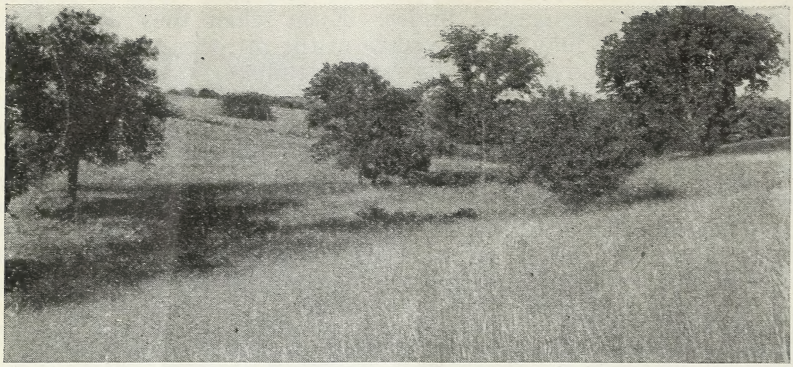

FIGURE 3.—A permanent sod protects the soil and gradually builds up the organic matter in the soil. (See also front cover.)

Grass, the Real Soil Builder

For real soil building it is necessary to turn to permanent sod. A permanent sod will increase the organic matter in the soil, chiefly by its root growth. A healthy grass sod produces new roots every year, and the decay of the old roots adds to the organic matter, most of which is retained because the soil is undisturbed. Gustafson, of Cornell University, cites a case where a virgin Illinois prairie sod was found to contain 27,000 pounds per acre of live roots. These roots die and are renewed constantly and in a comparatively short time really build up the organic-matter content of the soil. This indeed is doubtless the origin of the organic matter in most of the fertile lands of the central Corn Belt. In the forested area, however, where the organic matter has been derived from fallen leaves and the decaying roots of trees and other vegetation it has taken a long time to build up the organic-matter content of the soils, time that must be expressed in geologic terms rather than in terms of human generations. Trees build soil too slowly for man's immediate use. A grass sod, if not utilized, is therefore probably the only practical 100-percent soil-building cover. If it is grazed or if hay is taken off, it may be necessary to add plant food, but even then the protection from erosion that such a cover offers, together with the increase in organic matter by root growth, makes such a crop (fig. 3) the ideal of the soil conservationist. Of course all land cannot be treated in this way, and, in the main, crops should be called soil-conserving rather than soil-building.

It is quite possible by using proper crops, proper rotations, applications of lime and minerals where necessary, and approved anti-erosion practices to conserve our soils so as to prevent the steady decline in yields that has characterized soil-mining practices.

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